Screening Tables for Air Toxics Evaluation During Construction

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1.0 INTRODUCTION

This document presents a screening approach to conduct initial evaluations of potential health risks from exposure to toxic air contaminants (TACs), including diesel particulate matter (DPM), and particulate matter with an aerodynamic resistance diameter of less than 2.5 micrometers (PM2.5) from construction activities. DPM, PM2.5, and several TACs are all emitted from construction activity that uses traditional diesel-powered equipment such as bulldozers, generators, and cranes. The purpose of this report is to provide screening tables to estimate air quality health risk impacts associated with construction activity in accordance with the Bay Area Air Quality Management District's (District) proposed California Environmental Quality Act (CEQA) Thresholds of Significance.

The EPA has identified a group of 92 airborne compounds emitted from mobile sources as substances known to cause human health effects. Among these compounds, the EPA has highlighted the following seven as priority air toxics: acrolein; benzene; 1,3-butadiene; DPM; formaldehyde; naphthalene; and polycyclic organic matter (Federal Registry, Vol. 72, No. 37, page 8430, February 2007).

In 1998, the California Air Resources Board (ARB) identified DPM emitted from diesel-fueled engine exhaust as a TAC (ARB 1998). The Office of Environmental Health Hazard Assessment (OEHHA) has concluded that the cancer risk from a 70-year exposure to DPM at a concentration of 1 microgram per cubic meter ($\mu g/m^3$) ranges from 130 to 2,400 excess cancer cases per million people (OEHHA 2000). On a statewide basis, the cancer risk associated with ambient DPM concentrations is greater than 500 excess cancers per million people exposed (ARB 2000). The OEHHA also found that exposure to DPM results in a greater incidence of chronic non-cancer health effects, such as cough, labored breathing, chest tightness, wheezing, and bronchitis (ARB 2000).

Individuals particularly vulnerable to DPM are children, whose lung tissue is still developing, and the elderly, who may have other serious health problems that can be aggravated by exposure to DPM (ARB 2009). In general, children are more vulnerable than adults to air pollutants because they have higher inhalation rates, narrower airways, and less mature immune systems. In addition, children with allergies may have an enhanced allergic response when exposed to diesel exhaust (Southern California Environmental Health Sciences Center 2005.)

In addition to DPM, TACs from diesel exhaust contribute to both cancer and non-cancer health risks associated with construction activity. DPM has the greatest cancer risk by far of any TAC emitted from diesel fuel combustion, but does not have the greatest non-cancer risk. A multitude of additional TACs are emitted whenever diesel fuel is combusted, many of which have cancer and non-cancer health effects. Acrolein is one of the most toxic TAC associated with diesel exhaust based on its non-cancer toxicity value.

PM2.5 was incorporated into the District's CEQA significant thresholds due to the significant health impacts from recent health studies at the local level (BAAQMD 2009). An incremental increase of greater than 0.3 micrograms per cubic meter (µg/m3) annual average PM2.5 would be a considered significant. For this reason, PM2.5 emissions, and the associated downwind concentrations, are analyzed in this study.

2.0 SIGNIFICANCE THRESHOLDS

Significance for this study is based on the following District proposed significance thresholds:

1. An excess cancer risk level of more than 10 in one million, or a non-cancer (i.e., chronic or acute) hazard index greater than 1.0.
2. An incremental increase of greater than 0.3 μg/m3 annual average PM2.5.

This report presents draft *screening* criteria for construction-related health risks associated with development. This screening approach embodies many worst-case and conservative assumptions, which may not necessarily represent individual project-by-project characteristics and conditions. As such, a project-level health risk assessment (HRA) for a specific project would likely estimate considerably more accurate risks and likely lower than those estimated by this screening approach.

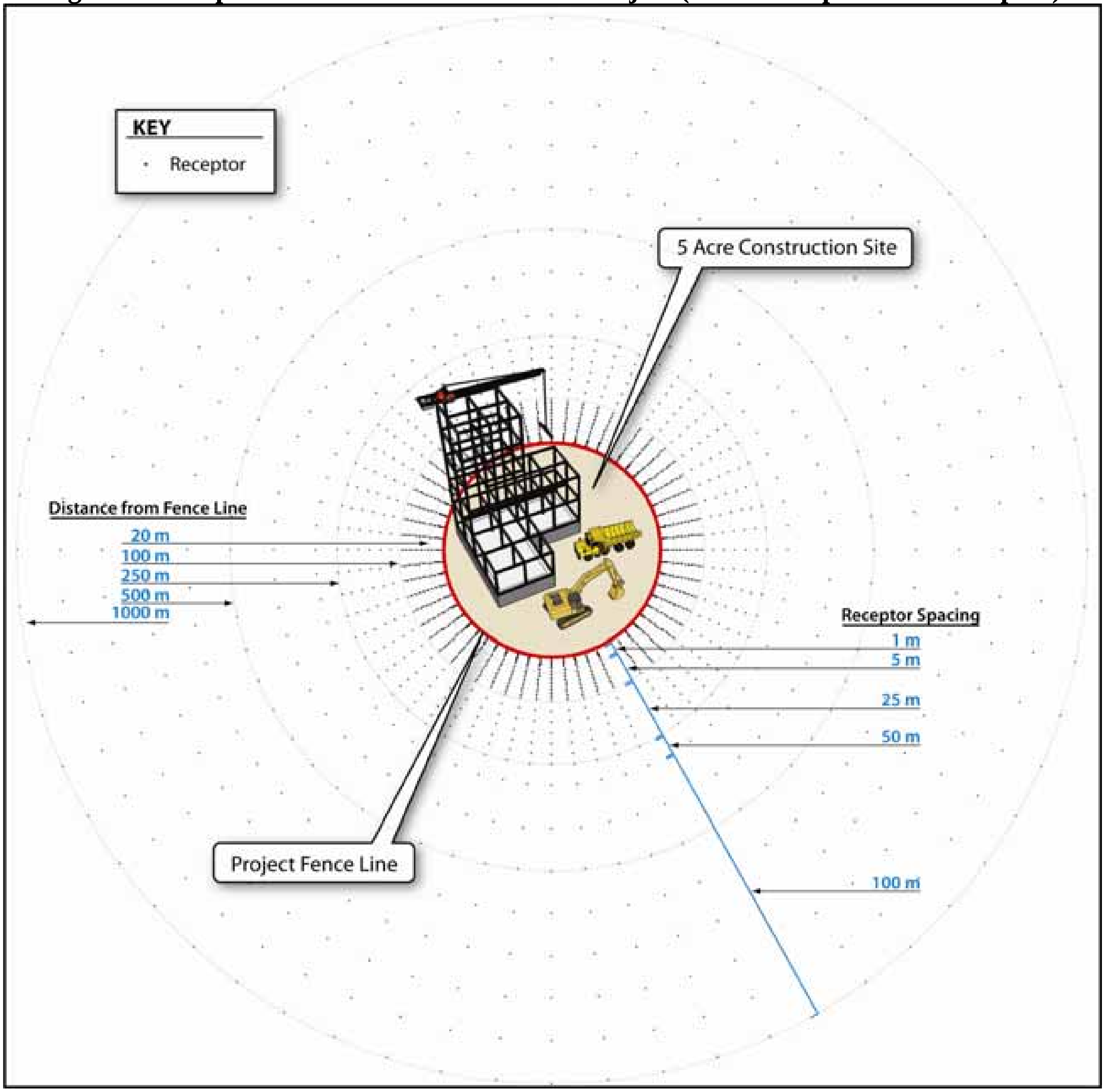
3.0 METHODOLOGY

This report characterized the health risks associated with construction emissions emanating from thirty typical residential, commercial, and industrial construction projects. Construction activity analyzed in this report includes off-road equipment (e.g. graders, backhoes, and water trucks) and on-road diesel haul trucks (required for exporting spoils and importing fill materials). All calculations and modeling inputs were based upon the most conservative information and assumptions available at the time of analysis.

The methodology used to estimate health risk from construction emissions follows standard modeling procedures and risk assessment practices. For this analysis, on-site construction activities were simulated as area sources and on-road activity was simulated as line sources. Using a unit emission factor, ambient concentrations downwind of the source were estimated for a variety of project sizes, vehicle flow rates, and meteorological conditions. Construction sites were assumed to be circular and ranged in sizes from 0.25, 0.5, 1, 2, 5, 10, 25, 50, 100, and 200 acres. Receptors were placed radially at increasing distances from each area source. Fifty receptors ranging from 1 meter to 1,000 meters from the source were input into ISCST3 at the recommended breathing zone of 1.8 meters in height. Receptors nearest the fence line were spaced 1 meter apart to capture the necessary level of detail and the sharp drop in concentration observed nearest the fence line. Receptors farther from the fence line were spaced at increasing distances, up to 100 meter. Figure 1 depicts receptor locations simulated for a five-acre project site.

Meteorological data for Contra Costa County, Alameda County, and Santa Clara County were used in the dispersion modeling. Based on consultation with the BAAQMD, data representing these three counties were obtained from the Concord Station (#2903), Lawrence Livermore National Laboratory Station (#1801), and the San Martin Station (#7901), respectively. These stations were selected because of the higher percentage of recorded calm wind conditions, below one mile per hour, that results in less mixing and higher downwind concentrations.

Figure 1. Receptor Locations for a Five Acre Project (each dot represents a receptor)



Emissions from on-road and hauling vehicles were calculated based on the assumption that the vehicles travel on a single-lane roadway. The emission strength of the roadway was determined based on estimated vehicle flow rate and EMFAC emission factors associated with hauling activity. This link was simulated in CAL3QHC with a link width of 10 meters (4-meter traveled way and two 3-meter shoulders) and an infinitely long line source (1,000 meters for this analysis).

The air concentrations predicted from the modeling analysis were then scaled based on actual pollutant emission rates for specific project types. The ISCST3 dispersion model was used to estimate dispersion from area sources and the CAL3QHC model was used to estimate dispersion for mobile sources.

The calculation of non-cancer risks was done following the OEHHA's *Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA 2003). Non-cancer risks were determined following the OHHEA methodology shown here:

Step 1: Calculate the inhalation chronic hazard quotient for each substance.

$$\text{Chronic Hazard Quotient} = \frac{\left(\text{Annual Average Concentration } \frac{\mu g}{m^3}\right)}{\left(\text{Chronic REL } \frac{\mu g}{m^3}\right)}$$

Step 2: Calculate the acute inhalation hazard quotient for each substance.

$$\text{Acute Hazard Quotient} = \frac{\left(\text{1hr Concentration } \frac{\mu g}{m^3}\right)}{\left(\text{Acute REL } \frac{\mu g}{m^3}\right)}$$

Cancer risks were calculated following the OEHHA's *Air Toxics Hot Spots Program Risk Assessment Guidelines* (OEHHA 2003). For the purposes of this analysis, cancer risk was assumed to occur exclusively through the inhalation pathway. To estimate cancer risk, the inhalation dose was calculated using this equation and recommended OEHHA default values:

$$\textit{Dose} = \frac{(C_{air})(DBR)(A)(EF)(ED)(1X\ 10^{-6})}{AT}$$

where

Dose = Dose through inhalation (mg/kg/d).
C_{air} = Concentration in air ($\mu g/m^3$), annual average from air dispersion model.
DBR = Daily breathing rate (L/kg body weight-day), 302.
A = Inhalation absorption factor, 1.
EF = Exposure frequency, from URBEMIS modeling.
ED = Exposure duration, from URBEMIS modeling.
$1X\ 10^{-6}$ = Micrograms to milligrams conversion.
AT = Averaging time, 25,550 days.

Using the inhalation dose, the cancer risk was estimated according to the following equation:

Cancer Risk = (Dose)(Cancer Potency)(1×10^6)

where

Cancer Risk = Excess cancers per million people exposed
Dose = Dose through inhalation (mg/kg/d)
Cancer Potency = Cancer potency factor for substance (kg-day/mg)
1×10^6 = Conversion factor

For cancer risk, the District has adopted OEHHA updated guidance for calculating cancer risk that accounts for the possible differences in risk associated with early-in-life exposures (OEHHA 2009). The OEHHA recommends using ASFs to weight exposures that occur early in life for prenatal, postnatal, and juvenile exposures such that a factor of 10 is used for the third trimester to age 2 years, and a factor of 3 for ages 2 through 15 years to account for potential increased sensitivity to carcinogens during childhood (see Table 1).

Table 1. Age Sensitivity Factors

Lifestage	Duration to Apply ASF	ASF
Third trimester to age 2yrs	2 yrs	10
Age 2 to age 16 yrs	14 yrs	3
Age 16 to 70 yrs	54 yrs	1

The OEHHA recommends that districts assume a minimum of 2 years of exposure and the application of a 10-fold ASF when assessing the health risks of short term projects:

> Assessing risks to short-term exposures to carcinogens involves additional uncertainties. The cancer potency factors are generally based on long-term exposures. However, in reality, the local air districts in California are frequently assessing risk from short term activities related to construction, mitigation of contaminated soils, and so forth. OEHHA recommends that when assessing such shorter term projects, the districts assume a minimum of 2 years of exposure and apply the slope factors and the 10 fold ASF to such assessments. Exposure durations longer than 2 years would use the method for the remaining years as noted above (OEHHA 2009).

4.0 SCREENING TABLE

Table 2 lists the minimum distance required between the fence line of a construction site and a nearby sensitive receptor to ensure that cancer and non-cancer risks associated with the project are less than significant per the District proposed significance thresholds. Table 2 lists the DPM, PM2.5, and acrolein risks separately. Acrolein was selected to represent all TACs because it has the greatest non-cancer risk factor (as discussed above). Cancer risks have been weighted by ASF proposed by the OEHHA, which account for the possible differences in risk associated with early-in-life and adult exposures (OEHHA 2009).

To estimate the minimum distance required between the fence line of a construction site to a nearby sensitive receptor to avoid significant health risks, the following approach is recommended:

1. If the project size (acres) is known, match the project size to the nearest project size in acres in Table 1.
2. If the number of units (residential project) or square feet (commercial or industrial projects) is known but the project size (acres) is unknown, match the project size to the nearest project size in Table 2.

3. If the project falls between two project sizes in Table 2, refer to the next largest project for a conservative estimate of screening distances.

4. Read across the table horizontally to determine the offset distance required for combined risk (far right hand column).

Example 1: To calculate the minimum offset distance to avoid significant impacts for a 75-unit residential project for which the acreage is unknown, select the 100-unit project in Table 2. The minimum distance required between the fence line of construction to a nearby sensitive receptor to avoid significant health risks would be 175 meters for cancer risk with ASFs, 20 meters for DPM chronic hazard, 150 meters for PM2.5, and 90 meters for acrolein acute hazard. The worst-case screening distance is 175 meters for cancer risk with ASFs.

Example 2: To calculate the minimum offset distance to avoid significant impacts for a 100,000-square-foot commercial development on 10 acres, select the 300,000-square-foot (13.8-acre) commercial project in Table 2. The 100,000-square-foot commercial project is not selected because an estimation of the project size in acres should be used in preference of the # of units or square feet developed. In this case, the minimum distance required between the fence line of construction to a nearby sensitive receptor to avoid significant health risks would be 200 meters for cancer risk with ASFs, 25 meters for DPM chronic hazard, 150 meters for PM2.5, and 85 meters for acrolein acute hazard. The worst-case screening distance is 200 meters for cancer risk with ASFs.

Table 2 is based on the conservative assumption that all on-road haul truck activity will occur on the fence line of the project site and all off-road construction activity will be concentrated on a ¼ acre area at the project fence line. The actual risk associated with a more realistic distribution of emissions will likely predict substantially lower risk than those listed in Table 2. It should be noted that a project that fails the screening procedure may or may not actually result in significant health risks associated with construction emissions. Project proponents should be aware that it is not unusual for a more detailed dispersion analysis and HRA can, in some cases, show that risks are less than significant. Thus, project proponents and CEQA lead agencies could choose to 1) assume that the risk is equivalent to that determined using the screening procedure and identify mitigation necessary to reduce to below the risk thresholds OR (2) conduct more detailed analysis to examine further whether significant risks are associated with their project and to determine more precisely what mitigation may be necessary.

The District considers the screening procedure provided in this report as environmentally conservative *interim guidance*. The District will update this screening procedure based on refinements of the modeling assumptions and based on stakeholder input and suggestions. The District is currently preparing an excel-based tool to facilitate detailed project specific health risk analysis. The District plans to release Excel-based risk analysis tool in the spring/summer of 2010.

Table 2. Draft Construction Health Risk Screening Table

Project Scenario			**Minimum offset distance (meters) from the project fence line to ensure that a sensitive receptor would have a less than significant impact**[1]					
Type	# of Units or Square Feet	Project Site Acres	**DPM**		**PM2.5**	**Acrolein**[2]		**Offset Required for Combined Risk** w/ ASF[3]
			Cancer Risk w/ ASF[3]	Chronic Hazard Index	Annual Average Concentration ($\mu g/m^3$)	Acute Hazard Index	Chronic Hazard Index	
Residential	5	1.7	95	7	75	55	1	95
	10	3.3	100	7	75	55	1	100
	25	8.3	125	16	100	85	6	125
	50	16.7	150	18	125	90	8	150
	100	33.3	175	20	150	90	11	175
	250	83.3	300	25	250	150	12	300
	500	166.7	400	35	300	150	20	400
	1,000	333.3	500	40	600	175	25	600
	2,000	666.7	700	45	900	225	25	900
	5,000	1,666.7	1,000	40	800	225	25	1,000
Commercial	5,000	0.2	100	8	75	55	1	100
	10,000	0.5	100	8	75	55	1	100
	30,000	1.4	100	8	80	55	1	100
	60,000	2.8	100	9	85	55	1	100
	100,000	4.6	150	19	125	85	8	150
	300,000	13.8	200	25	150	85	13	200
	500,000	23.0	225	19	175	85	8	225
	1,000,000	45.9	300	25	200	90	14	300
	3,000,000	137.7	500	35	400	150	20	500
	7,000,000	321.4	600	35	400	175	20	600
Industrial	5,000	0.2	100	10	85	55	2	100
	10,000	0.5	100	10	85	55	2	100
	30,000	1.4	100	10	90	55	2	100
	60,000	2.8	100	11	95	55	2	100
	100,000	4.6	175	20	125	85	10	175
	300,000	13.8	200	25	175	85	15	200
	500,000	23.0	250	20	175	85	9	250
	1,000,000	45.9	300	25	200	90	15	300
	3,000,000	137.7	500	35	400	150	20	500
	6,000,000	275.5	600	35	400	150	19	600

Notes:

1 The District thresholds are an increased cancer risk of 10 in a million, a hazard index of 1, and a PM2.5 annual average concentration of 0.3 $\mu g/m^3$.

2 The OEHHA proposes weighting cancer risk by a factor of 10 for exposures that occur from the third trimester of pregnancy to 2 years of age, and by a factor of 3 for exposures that occur from 2 years through 15 years of age. These factors are called Age Sensitivity Factors (ASF). The methodology for applying ASF to cancer risk is discussed in the documentation sections above.

3 Acrolein was chosen because it has greatest non-cancer health risks for toxic air contaminants contained in diesel exhaust.

5.0 LIMITATIONS

The screening criteria presented in Table 2 should be used only after careful consideration of the modeling assumptions and methodology utilized in this study. Screening approaches characteristically include many worst-case and conservative assumptions, which may not necessarily represent individual project-by-project characteristics and site conditions.

When utilizing the screening table (Table 2), the following considerations must be taken:

1. The screening table is meant to estimate construction-related health risks based on general project characteristics, such as type (residential) and size (number of units or acres). It should not be used to estimate health risks from construction of non-standard or particularly complicated projects.

2. The screening table is based on a general selection of project sizes. For projects that fall between sizes in the screening table, users should refer to the next larger project size for estimated health risks. It is not recommended to extrapolate health risks for intermediate size projects.

3. The screening table is based on general project assumptions outlined in the *Methodology* section. These include the total duration of project construction, duration and overlap of individual construction phases[1], and default air quality model equipment fleets. The screening table should not be used for projects with substantially different characteristics (such as longer phases, phase overlap, or more extensive construction equipment use).

4. The screening table assumes no overlap in construction phases. As such, the screening criteria are not adequate for projects with overlapping construction phases. Phase overlap can result in significant short-term exposures to toxic air contaminants such as acrolein.

6.0 REFERENCES

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[1] A construction phase is a particular subset of construction activity necessary to complete a certain portion of a project's construction. Phases may include a specific fleet of construction equipment operating for a specific period of time. The construction phases analyzed in this study include grading (horizontal construction including site preparation, soil movement, excavation, etc.), paving (laying pavement, asphalt, and foundations), and building construction (vertical construction of the facility once site grading and paving have been completed).

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